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NOVA.

The Chip vs the Chess Master

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The Chip vs the Chess Master

ANNOUNCER: Tonight on Nova: A chess match with the highest of stakes. This man is the world champion. His opponent: a computer. A game of enormous mathematical possibilities, chess has always been a test of human intellect.

GARY KASPAROV: The idea of the game is still the same: to destroy your opponent's ego, your opponent's mentality, even if it's a computer mentality. It doesn't matter.

ANNOUNCER: Who will be the ultimate champion when man squares off against machine in "The Chip vs the Chess Master"?

BRAD LEITHAUSER, Author: Even if you don't understand how to move chess pieces, what you have here is the phenomenon of how we define ourselves in relationship to the machine.

NARRATOR: The machine has a name: Deep Thought. It's the computer world champion of chess. Across the board is Gary Kasparov, the human champion, maybe the best chess player who's ever lived.

GARY KASPAROV: I mean, the idea of this match is much wider than chess itself. It's a man versus the computer and right now, watching this enormous development of the computers, and people probably have this fear. It's very deep, still. But it's a fear— who knows? Probably in the future, computer will replace us, I mean, will control our life. And chess is probably the only— the only kind of activity, human activity, when you can compare our ability and computer.

NARRATOR: This has never happened before, not at this level of the game, a game that's come to represent complexity and intelligence of the human mind, the ability to think. In this arena, man has been unchallenged until now.

ROBERT BYRNE, Chess Grandmaster: It is nice to think that no matter what these wonderful computers can do, they can't beat me at my game, by George! And that's gone, or rather it's rapidly coming to a close. We never thought that a computer would play at Grandmaster level, and here's one already doing it.

NARRATOR: Chess may be only a game, but not for the Grandmaster or for the scientist.

JONATHAN SCHAEFER, Computer Scientist: But I think the whole notion of man versus machine, you know, it goes really to the heart of human instinct because we invented the machine. It's our creation. And in some sense, to have this machine be better than us— I mean, this is almost a foreboding of a lot of the things that have happened in science fiction stories that we put off as being near-fantasy. But unfortunately or fortunately, depends on your point of view, these days may not be that far away.

NARRATOR: On this day, a game of chess has stirred new possibilities and old feelings.

HERBERT SIMON, Professor of Psychology: The same emotions have been aroused whenever one talks about computers thinking and that, in turn, it seemed to me, to have something to do with the fact

that many human beings seem to get their feeling of dignity, worth, self-respect out of some notion that the human species is different from everything else, from some idea of uniqueness. And of course, then, if you take away some kind of uniqueness, that's very upsetting and I guess there were some guys who were very upset when Galileo said, or Copernicus, you know, "You aren't right in the center of things."

NARRATOR: In the moments before their match, the adversaries are at the center of a brave new world of chess and the microchip. Like fighters before a title bout, they are pressed for clues to the outcome and meaning of their confrontation.

HANS BERLINER, Computer Scientist: I think you're right, but one has to be a good tactician and very patient.

Mr. KASPAROV: No, that's true. That's why I say that if computer is much more powerful—

1st REPORTER: Do you feel bad that what you may be doing is, like, taking away the human creative, you know, soul?

FENG-HSIUNG HSU, Deep Thought Team: I don't think it's taking away the human creative soul, because in a sense we are creating something that's human, try to duplicate a human's behavior in some sense.

1st REPORTER: You're not trying to create a super-super, you know, thing that's unhuman, that's better than human? Can you do that?

Mr. HSU: We're trying to build something that's better than all humans in a specific domain. Now, what does that do? Unclear?

1st REPORTER: But doesn't that necessarily have broader implications?

Mr. KASPAROV: Because in chess, you have to win the chess game. If you can win, I mean, 70 percent or 75 or 60—

1st REPORTER: You have Kasparov sweating over there— he's talking about representing the human race.

Mr. HSU: Well, we prefer to think of Kasparov as a willing participant in the experiment trying to measure the human limitation in chess intelligence.

SHELBY LYMAN, Chess Writer: OK, we're ready to start. Could we have quiet, please?

NARRATOR: The experiment is being conducted at the New York Academy of Art, an unlikely laboratory for what became a media event.

Mr. LYMAN: I'd like to introduce the protagonists. First of all, from Carnegie-Mellon University, where they created this — they're now at IBM, incidentally — I'd like to introduce the men and the brains behind Deep Thought, Murray Campbell and Feng-Hsiung Hsu.

INTERVIEWER: And can you describe what it was like the day you played Kasparov, what the atmosphere was like in that room?

Mr. HSU: Hostile.

MURRAY CAMPBELL, Deep Thought Team: It seemed like almost all the people there were rooting for Kasparov except for maybe a few people in computer science who were rooting for the computer.

THOMAS ANANTHARAMAN, Deep Thought Team: I was at Carnegie-Mellon where the actual computer was located at that time, and we had a small room set aside for spectators, so we assumed they'd all be, you know, people who are familiar with Deep Thought and who would root for Deep Thought. But even there, almost no one was rooting for Deep Thought. Almost everyone was hostile.

Mr. LYMAN: And now I'd like to introduce a very young man, incredibly young for what he's accomplished, from Baku in the USSR, a man who, at 26, can— can very reasonably claim, and he's being heralded as such, as the greatest chess player in history. I'd like to introduce the champion of the entire world in chess, the world champion, Gary Kasparov.

KEN THOMPSON, Bell Laboratories: I mean, this is something. This is an event. Kasparov— there has been no one like him in the chess world since Fischer that generates this kind of emotion, you know, this sort of hero-worship, you know, bad guy, bad boy kind of— kind of, you know, emotions that— he's just perfect to be the first person to go in— you know, the first world champion to go in with the emerging strong chess programs.

2nd REPORTER: Gary, if you were to lose in the next few years to some super-machine, what effect do you think the loss by the world champion to a machine will have on chess as a creative and as a business enterprise?

Mr. KASPAROV: You mean in the next five years?

2nd REPORTER: Well, whatever—

Mr. KASPAROV: OK. Thank you. It means that I will be world champion for next five years. Thanks for this compliment. Yeah, I understand. I think we will find enough ability, human ability, to fight especially against the computer. But if computer beats, one day, I don't know what will happen. I don't think that chess will be stopped, but it will be very unpleasant, not only for the chess players but for the human race itself, because it mean that you— you can provide better mind than the human one.

NARRATOR: A thought unpleasant to some has inspired others who would turn smoke and fire and metal into a mechanical Grandmaster. This French film, *The Chess Player*, told the story of an 18th Century Hungarian nobleman who claimed to have done just that 100 years before Frankenstein's monster.

The idea has always attracted a crowd, as it did at the royal courts of Europe whenever the Turk came to play. Then, as now, the claim that a machine could think for itself had to be proven to a skeptical audience. What the public saw was a complex automaton whose gears and levers were carefully charted and studied. The Turk was one of the most popular and successful chess players on the continent. Kings smiled. So did the inventor. But not Napoleon who, it's said, was beaten in 19 moves.

The Turk had many imitators: Mephisto, "the marvelous mechanical chess player"; Ajeed, "the greatest wonder of the 19th Century." But there was one thing all these early mechanical players had in common. Concealed inside the machine or in a nearby room, a human chess master operated the controls. They were all fakes. The first machine that could play on its own didn't appear until early in the 20th

Century. This chess contraption of pulleys and weights, of wires and electromagnets, could play a simple end game and find the winning move every time. That's where automated chess stayed until the 1950's and the electronic age.

Prof. SIMON: As far as machines are concerned, chess became, very early on, a challenge to see how far we could carry computer programming into the realms of what is usually regarded as human intelligence and chess is usually regarded as something that requires deep thought. I guess that's why they named the program that. So it seemed to be a very good area in which to test our ideas of how you can program a computer to be intelligent.

SCIENTIST: *[University of Toronto, 1959]* Our research work has as its prime motive the investigation of human thinking processes using the electronic computer and also the game of chess.

NARRATOR: It was provocative, promising and primitive. In 1959, the idea was to create an artificial intelligence, a machine that thinks, the way a human thinks.

SCIENTIST: *[University of Toronto, 1959]* The machine is now being given the instruction to prepare its next move. It is in its thinking process now, which lasts for approximately six seconds. Three thousand individual calculations have been done. The machine indicates its move by means of the console lights, which indicated that it has moved the pawn one square forward.

NARRATOR: One square led to another and another. For computer scientists, it was an intriguing challenge since chess depends on a well-defined set of rules and a finite, if immense, range of possibilities. It was programmable and once a machine could be programmed to play, why not to win? That was human nature.

Mr. SCHAEFER: It's been a dream, one of the initial dreams of computing science since computers were first invented 40 years ago, to be able to build a machine or, in those days, write a program, that could defeat the human world chess champion. It was just posed as an interesting problem and it's been 40 years that we've been working very hard on this problem.

NARRATOR: At first, programmers thought they could succeed by imitating the human player. But by the late 1970's, as computers grew more powerful, scientists began to rethink how the computer game could approach the highest level of play. To beat humans at their own game, it would have to be done the computer's way.

Mr. THOMPSON: You think the human mind is something special. It's more than just a machine. And when you're beat by a machine at something that's considered to be the epitome of intellectual— intellectual activity, something— something happens. I mean, either the notion of intelligence or chess or something has to change when this happens.

NARRATOR: This may be a place to study the nature of problem-solving, the potential of the computer. But that's not on the mind of Gary Kasparov as he sits down to begin play against the first computer good enough to challenge a world champion.

MATCH OFFICIAL: I'm going to start the clock now. Everyone needs to be quiet. No more talking, please.

NARRATOR: In the game of chess, every move counts, forming a pattern of attack or defense. The power and role of each piece is determined by its relationship to other pieces on the board. A pawn may be the weakest piece, but on the right square at the right time it can threaten a king. Both man and machine have the same goal, how, in every position, to find the best possible move, but they won't find it in the same way. Kasparov calls upon every resource of memory and knowledge, of imagination and inspiration. Deep Thought does what a computer does best: crunches numbers, millions of them.

Mr. SCHAEFER: Computers deal with ones and zeros and add and subtract. The Grandmaster deals with initiative, momentum, attacks, defenses. He can't even explain some of the things that he did. If you asked Gary Kasparov why he made a certain move he'll say, "Well, it was just the right move," or "It feels right."

NARRATOR: What Gary Kasparov knows is the weight of history, the burden of defending a tradition traceable at least to the 6th Century, to India or Persia. When the Caliph of Baghdad was asked "What is chess?" he answered "What is life?" For the faithful, the 64 squares hold incomparable beauty and impenetrable mystery, a game whose possibilities haven't been exhausted yet, a puzzle that may never be solved— not entirely.

The origins of chess are linked to games of war, to intricate maneuvers, a game of cunning and courage played by warriors of the mind.

Mr. KASPAROV: This fight between these two egos, two intellects, it's the essence of chess, you know? It's essential point of our struggle. And that's why I think that chess is a very violent sport because having match, like Kasparov/Karpov, you are trying to destroy the ego of your opponent and it's two very strong wills. And if you win, it's a big psychological shock for another player.

PATRICK WOLF, Chess Grandmaster: In order to want to compete at chess, in order to want to win at chess, it probably takes a certain type of personality. You need to be very competitive. You need to have a very large ego, really a strong desire to beat someone in some sense.

MICHAEL VALVO, Chess Computer Specialist: A lot of ego, a lot of resolve, a lot of determination, a lot of arrogance. Then we get down to talent. That's the last part and if you ain't got the talent, you ain't going to make it. And you've got to want to win.

Mr. KASPAROV: I have to destroy. I have to— I am human. I have to remember that this is the special strategy, how to show the computer's consequences and how to avoid the unpleasant positions for me. And that gives me more confidence playing against computer than if I play versus strong player. But the idea of the game is still the same, to destroy your opponent's ego, your opponent's mentality, even if it's computer mentality. It doesn't matter.

NARRATOR: To outwit a computer's mentality, Kasparov has prepared for Deep Thought as he would any other opponent, by carefully studying 50 of its previous games. Playing the white pieces, Deep Thought moved first. Kasparov chose a Sicilian defense named for an Italian priest who first recorded the move in the year 1617. After 10 moves and an exchange of minor pieces, the game is fairly

even.

Mr. CAMPBELL: It's about ready to play. Oh, it's coming up— and that gives it a score— it thinks it's got almost half a pawn advantage, at this point. It thinks white has a very strong position in this— in this particular configuration. White has a very strong, dominating position in the center and Deep Thought likes that sort of position.

NARRATOR: The game's mathematical limit is vast. For the machine, speed is essential. The faster the computer, the more positions it can examine.

Mr. CAMPBELL: It's looking at close to 700,000 chess positions every second as it's calculating this. And by the time we're done, in maybe a minute, that's, you know, 5 million, or, sorry, 50 million chess positions.

NARRATOR: Chess may be both art and science, but in the computer chess game it's also engineering. Carnegie-Mellon University, birthplace of Deep Thought, is a pioneer in the quest to build a chess machine better than any human.

ALLEN NEWELL, Professor of Computer Science: So Deep Thought starts, when it's making a move, by setting out a little chess board. So there it is, OK? And the game of chess is played by making moves from this. This is where the actual game of chess is played is by making moves from this, which moves to a new chess board at which point — let's use another color — at which point the opponent— so we'll put human in red and this in blue, OK? The human opponent makes a move and then— and that's where the actual game would go. Deep Thought makes a move. Human makes a move. Deep Thought makes a move, OK? If you're sitting here trying to make a move, then the question is, "Is that the right way to go?" There are other things that you can do, OK? So, in fact, you might look at this or this or this.

NARRATOR: At the chess board, it's not a matter of luck. There's no roll of the dice. To begin the game, there are 20 possible moves. After one move by each side, the number of possible board positions increases to 400; after three moves, to more than 20,000. By mid-game, to look ahead several moves involves possibilities in the trillions. To find the best move, Deep Thought must look at every possibility that time allows, at a game tree whose branches extend in every direction the game can take.

Prof. SIMON: There's no way in which any computer present or prospective could play out all the branches of the game tree. You can get various numbers to estimate how big that is. They used to say 10 to the 120th, but that's probably too big. It's probably only, like, 10 to 50th. Well, that's a number that's an order of magnitude of the number of molecules in the universe.

Prof. NEWELL: And so the problem sitting here, if— I don't know. That's the human, I guess. I don't know what Deep Thought— Deep Thought looks like this. It's got squares or something like that. OK? So if this is Deep Thought, not the human here, it's got to consider all the different ways the game might go. Someplace out here — so let's take it to here — someplace out here, a good thing happens, Deep Thought— from Deep Thought's point of view. Deep Thought, in fact, takes a rook. It takes something, takes a piece of material off the

board. In that case, then that's a big plus for it. But if that's the case, the human is certainly going to see that, right? So the human certainly isn't going to go do that move. The human's going to go and take this move for which, in fact, we may go way out here some more before good or bad things happen.

NARRATOR: The computer determines which moves are good or bad by its evaluation function, which assigns a numerical value to each piece on every square of the chess board.

Prof. SIMON: So Deep Thought is partly number-crunching, but partly more generally symbol-crunching because it's look at actual chess positions scored in the computer, but the symbols there don't represent the numbers from 1 to 10. The symbols there represent queens and pawns and rooks and so on in a certain geometrical relation. We know how to program a computer memory so it'll keep that geometric information around sort of like a— well, like your mind's eye, like a mental image. And what it does is to say, "Well, if I made this move and the board was changed in this way, what would it look like then?" The number-crunching is all at the end of this process. When it finds a position it wants to evaluate, then it says, "Oh, I've got," you know, "two rooks and a bishop and a knight and that's worth 16 points" and so on. "And I've got this center control and so forth and that's worth so much." So it kind of adds it up.

Prof. NEWELL: So here you are, sitting back here at the beginning where none of these moves have been made, OK? And the other problem is to go out and search, which is why we always talk— search out and when you find things, to realize what the opponent would do and therefore what you ought to do in order to find out that in the long run, this one didn't work and that one doesn't work, but this is, in fact, the best one that you can see in terms of how far out you can you, OK? And so that's what's called the "search of"— this is called the "game tree." Doesn't look much like a tree, but if you turned it this way and drew it up like this, then it would look like a bush growing up. It's called the "game tree" and this is called the "search of the game tree," deciding whether there's a plus or you lose a rook out there or the position is simply bad for you. You're all cramped in one corner. That's called the "evaluation function." And that's how these things play chess.

Mr. CAMPBELL: Well, I can start the program and what it does is, it searches down to a depth of four. That means it looks ahead two moves for white and two moves for black and comes up with a value. In this case it thinks the value is four. That means it's slightly better for white. And it wants to play the move E-4. Then it comes back and does the whole thing again, except doing it one move deeper. So it searches ahead three moves for white and two moves for black. So that's five, what we call "ply." And in that case, it changes its move and it plays a different move, knight to C-3. And then we continue this process. It's called "iterative deepening." You go deeper, step by step. Now it's going six, seven, eight. And then it'll reach this maximum depth that it's set. We call that the "horizon." And then at that point, it's going to evaluate the position. The whole search through all these possibilities, the goal is to find the line of play that leads to the best position, the position with the highest value for the player that's

on the move.

NARRATOR: The prototype for Deep Thought sits on the floor of an engineering lab. It was built for a few thousand dollars from scraps by a graduate student who didn't play chess.

INTERVIEWER: This is Deep Thought? What are we looking at?

Mr. HSU: You're looking at what's normally called a "printed circuit board" and there are two processors on this. Each processor can process about 400,000 chess positions per second. And combined together, depending on the software, it can examine between 700,000 to 800,000 positions per second. And the call to both processors is a so-called "chess move generator." Here is a blow-up, microphotograph of the chips and it can, it has a nice eight by eight patterns. And it's essentially a silicon chess board. Here is what it physically looks like, of chips. On this one, each one is a chip and each one of them is a chess move generator.

NARRATOR: A silicon chess board packed neatly into two microprocessors generating close to a million positions a second. That's the hardware which allows Deep Thought to search out all possibilities up to five moves ahead and which, in the eyes of a human champion, can produce unexpected results. Deep Thought has failed to perform a special maneuver to protect its king, called "castling." Either Deep Thought has found something Kasparov doesn't see or it has made a mistake. Either way, the computer is carried forward by the power of its massive search, playing the subtle and cerebral game by what's called "brute force."

Mr. CAMPBELL: The core of Deep Thought is its brute force search and that's how it generates all its ideas — quote — "ideas" — its moves and so without that, Deep Thought would not play very well at all, without a brute force, a very large brute force search.

NARRATOR: Brute force— the red light indicates the depth of the search. A special program called "singular extension" helps Deep Thought identify and look deeper into especially promising moves, something it must do to be competitive. To demonstrate singular extension, Deep Thought comes up with a memorable move from a 1938 game between world champions, the Russian Botvinnik and the Cuban Capablanca. It took Botvinnik examining this one position 30 minutes to find the winning move. Deep Thought finds it in 10. Singular extension gets more out of the computer's search and may bring Deep Thought to see as many as 20 moves ahead in complicated positions.

Mr. SCHAEFER: A human looks at one or two positions in a second, maybe 100 positions, when it's considering a move. Deep Thought looks at several million a second. And when you take this over an average three-minute move, we're talking 100 million positions, something like that. Very, very little knowledge, lots of engineering.

NARRATOR: For Deep Thought, a little knowledge goes a long way, but not without a code of commands that weighs almost five pounds. In tournament play, there are time limits. For Deep Thought, that means a trade-off between time spent on search and time spent on knowledge, including its evaluation function. The Deep Thought team believes more speed alone, a deeper search, will be enough to win, but they're taking no chances.

Mr. ANANTHARAMAN: You need some minimum amount of knowledge and of course the more knowledge you have, the less speed you need. But the way we look at it is that if you can add a little bit of extra knowledge, that gives us an extra margin of safety in achieving our goal to beat Kasparov.

NARRATOR: More has been written about chess than for all other games combined. What Kasparov brings to the chess board includes 1,000 years of recorded history and wisdom of which Deep Thought knows very little. The computer game is speed and search, not knowledge, but it needs to know some things that only a Grandmaster can teach it.

MAX DLUGY, Chess Master: One thing that Deep Thought is lacking is hundreds of years of chess experience and that kind of experience is necessary for Deep Thought to perform, you know, on the top level. And—

INTERVIEWER: Can you provide a computer with that kind of experience?

Mr. DLUGY: Yes. And this is particularly what I'm doing, trying to provide Deep Thought with that kind of experience.

NARRATOR: Deep Thought doesn't think for itself or learn from its mistakes. To fine-tune its performance, the computer is given classic chess problems. If it fails to solve them, its program is reexamined with the help of one of America's best players, Max Dlugy.

INTERVIEWER: Have you played Deep Thought?

Mr. DLUGY: Oh, yes, many times.

INTERVIEWER: What was the outcome? How have you done?

Mr. DLUGY: I don't know. I guess Murray takes— he keeps the tally.

Mr. CAMPBELL: Max plays provocative things to try and discover more weakness in the program, so he doesn't necessarily always play what he thinks is the best move. He'll play a less good move in order to test out some idea.

Mr. DLUGY: There are certain limitations for Deep Thought now and it's going to be a question of whether brute force will, you know, beat out pure intellect.

NARRATOR: That question has aroused enough curiosity to bring Anatoly Karpov to IBM on a rainy holiday weekend. The world champion for 10 years, no one has won more chess tournaments than Karpov. And no one like Karpov has ever come to IBM, not to play chess. Karpov had been surprised, stunned, by an earlier game he'd played against Deep Thought, which he was almost forced to draw. Today isn't a rematch but a chance to compare his chess thinking with the computer's calculations.

YASSER SEIRAWAN, Chess Grandmaster: The computer is considering every conceivable possibility, but I don't have to pretend that I'm seeing everything in the position. I make no such pretensions. In fact, I discard 99 percent of all possible variations. What I'm seeing almost as instantly as Deep Thought is calculating and reassessing thousands of variations is the soul, the heart of the position and I'm right there.

NARRATOR: How humans play chess hasn't changed in 500 years.

Deep Thought is driven by electrical impulses that produce a brute force search. Soviet Grandmasters like Lerner [sp?] and Tal, known as "the magician from Riga," respond to more inexplicable urges— instinct, intuition, ingenuity. The computer doesn't know this side of the game or the hero-worship it can inspire.

Mr. KASPAROV: There is such great difference between computer's operation and human. Chess is not only pure calculation, you know? Even if computer calculates millions of positions, it will still have to evaluate, to— not to *[unintelligible]*, but just to understand the position itself. I mean, common sense. I mean, that's our advantage. I want just to be the man who will save our pride, human pride.

NARRATOR: How the machine plays chess is understood, programmable, at least by computer scientists. At the chess board, it's man who works in mysterious ways. For the human player, chess is a game of nerves as well as knowledge, of psychological gambits, a test of wills and competitive spirit. None of that will matter to Deep Thought.

Mr. BERLINER: My own feeling is that we're going to finally shake the idea that everything has to be done in man's image. We're going to find out that man, as marvelous as he is, evolved to meet a set of needs and that there are all sorts of other needs which man has himself created which machines probably deal with much better than man can do himself. And I think this is going to be an example of that.

NARRATOR: In a chess game, humans can suffer lapses of concentration or memory and commit blunders. Computers have bugs. A bug had delayed Deep Thought's castling maneuver, costing it time and wasted moves. In pieces, the game was still about even, but the initiative had shifted to Kasparov. Deep Thought's strength is tactical, short-range, the ability to analyze a specific position. Its weakness is long-range planning, strategy, the very heart of the human game. No one knows this better than Robert Byrne, a Grandmaster and regular sparring partner for Deep Thought. In a series of games, Byrne has tested the machine's capabilities, strategy and tactics.

Mr. BYRNE: I'm bringing things around to the queen's side. I want to attack.

INTERVIEWER: I mean, is Deep Thought at this point doing things that a human opponent would not be doing?

Mr. BYRNE: Well, yes, it— Deep Thought has been having trouble forming a plan. And a human would try something, even if incorrect, would try to become more active. In the beginning, D.T. can play second-rate strategy, which it did here, misplaced some pieces. But once the pieces are on the squares where D.T. puts them, it slowly integrates them, given time. So it makes use of the situation in which it finds itself. That's not just in this game. D.T. does that.

NARRATOR: Byrne has won and lost against D.T. and familiarity has bred respect.

Mr. BYRNE: The outlook for humans is not too good because the two games that I won from Deep Thought were very beautifully played by me. Now, if that's the only way— you see the point. If that's the only way Deep Thought can be beaten is by doing a virtual *tour de force*,

then in the long run, unless you can think up some other way to beat it, it's going to come out ahead because you can't turn these out every day. The first game that I won from Deep Thought contained the best combination I've played in at least 10 years.

NARRATOR: But Byrne plays on, drawn to the challenge, analyzing, even marveling at the computer's game.

Mr. BYRNE: You see, there's a pin on that rook, but not after this, there isn't. You see, the rook is defended now by two pieces. My rook is attacked. So— and I was thinking of doing this because my game is now very bad. I was thinking of, and probably should have, you know, just given up the exchange here.

Mr. KASPAROV: You can't make a mistake. You can't lose your concentration. If you are doing it pretty well 40 moves, you must find the best 41st move because it's— that's the greatest advantage of the computer, it's stability. Computer doesn't lose hope. Computer doesn't care about, I mean, previous mistakes, no psychological hesitations.

Mr. BERLINER: The machine will see some cleverness that the human being had not conceptualized. And I see that all the time with Hightech and with other computers. They do things that are very difficult for humans to understand. And for instance, on defense, they will defend like iron. They see all the possibilities and they very objectively deal with all of them, try to ward off the most dangerous ones and maybe have to accede to the less dangerous ones, whereas a human being usually collapses under that kind of pressure and eventually makes a mistake and loses.

Mr. BYRNE: Some people are very upset by this. They don't like the idea of a machine triumphing. But you can look at it another way. In other words, these geniuses, Feng-Hsiung Hsu, Murray Campbell, Thomas Anantharaman— that's a human achievement, what they did. So D.T. didn't put itself together. Humans did.

NARRATOR: There are men behind the machine. Here at IBM, the team that created Deep Thought as graduate students have proven that whether or not a computer can think, it can, in this field, compete. Deep Thought is the first computer to play at Grandmaster level, compiling a list of important victims that grows as it gets deeper and deeper into the game.

Mr. KASPAROV: It's very important that they refuse to follow the traditional way, to copy our brains, our minds. And they try to use all the computers invented, calculational, relational, et cetera. And that's— that's the best way now, but I still am not sure that the computer will beat world champion, because it's different to beat players, chess players, strong chess players, stronger masters, even contenders, and the world champion because the world champion is absolutely the best and his greatest advantage, his greatest ability is to find a new way in chess and it will be something you can't explain to a computer.

Prof. NEWELL: The big issue of psychological interest about what lets a Kasparov play the kind of chess and show the kind of performance given, for instance — he would not like this way of saying it, I am sure — given that he only can search a little bit.

Mr. KASPAROV: You have to feel the chess game. You have to feel

the harmony of chess pieces on the board, beyond the computer's capabilities, no doubt. And I'm sure it won't be available even in the future.

NARRATOR: The positions have been staked out. In the opening, the two sides had maneuvered for control of the center, for influence over as many squares as possible, for mobility and striking power. Now they are ready to engage their forces, to begin the battle of the middle game. Deep Thought has been forced into a defensive position, but defense is what the machine plays best. It's Kasparov who will launch the attack. Tradition and culture have bestowed upon the world chess champion an aura of mythic mental powers that will not be easily conceded to a machine, not by Gary Kasparov. For as long as chess has been played it's been analyzed, a ritual that draws the chess crowd to a near-by room and fills it to capacity.

Mr. LYMAN: It's an interesting idea. I don't know if it works. See, one of the beautiful things about chess is its complexity. Humans have so many different ideas and there are games and positions still in the Fischer/Spassky match in '72 that haven't been clearly explained— I mean, in any games. Of course, computers are threatening, in the long run, to take some of that mystery away, some other thing that puts the human on the frontier of knowledge.

And the machine comes back. We don't have to explain this any more. We know why it's doing that. It doesn't see anything else to do. It's just waiting.

The rook took at D-1. The computer is playing on, but he's a piece behind. And indeed, the computer— it was correct in evaluating some moves ago that its position was worth a piece less. Did it see all this? I don't know.

NARRATOR: By this point in the game, Kasparov's assault has caused Deep Thought to mark time, looking in vain for a counterattack.

Mr. LYMAN: Murray, can you just explain how resignation takes place?

Mr. CAMPBELL: It'll say "I give up." We discussed before the game, when the evaluation function got below a certain level, we would resign, and it hasn't gotten below that level yet so—

Mr. LYMAN: What is that level?

Mr. CAMPBELL: But it has— it was 700 points, which was— a pawn is 128 points, so that's about four pawns.

NARRATOR: And then, after 52 moves, it was over.

Mr. LYMAN: Rook to E-2 by Gary Kasparov and in this position, the computer admits defeat.

Mr. HSU: I think there's always— there's a man versus machine element involved. I guess since the beginning of history, people has always had fascination of creating his own equal and this sort of is a step toward that dream. Of course, it's a first step, but it's interesting, anyway.

NARRATOR: After two and a half hours, Kasparov had prevailed, but it was like no other game he had ever played.

Mr. KASPAROV: Should I explain something?

Mr. LYMAN: Yes.

Mr. KASPAROV: OK. I did it well. Before the first game, I was a little bit worried because playing versus human being, I have my opponent opposite me and it's kind of energy goes between us. But today there's no human being and there was no energy. It's kind of black hole. But I discovered a new source of energy because I play this computer and the audience is human beings. Everybody wanted really to crash the computer because we all have— we have something common. We are human being. And thanks very much for this enormous energy supply.

Mr.LEITHAUSER: You know, people felt vindicated today, it seemed to me. We, humanity, had a common— had a common tribe. The computer people, of course, are always saying that, you know, that their triumph is a triumph for humanity, as well, and that isn't this— you know, this is one more reflection of all these things that we, you know, are capable of and are— what we can create. But we don't emotionally feel that way. I mean, we root for the lone— the lone Kasparov, here.

NARRATOR: For many, the unthinkable had been avoided. For others, what lay ahead was the inevitable. Back at his drawing board, Hsu is working on what he calls "the ultimate chess machine," one that by running 1,000 chips in parallel will look at a billion moves a second and become champion of all the world.

INTERVIEWER: So once you can look at a billion board positions a second, you've got it?

Mr. HSU: That's the way I figure it, yeah.

INTERVIEWER: Is it just a matter of time before Kasparov is defeated by Deep Thought or by Deep Thought's successor?

Prof. SIMON: I think so, a matter of not a very long time.

Mr. THOMPSON: Yes. In the forever future, yes. Yes. Something that a three-year-old will hold in their hand will beat the world champion. There's no doubt about that.

Mr. CAMPBELL: It's inevitable. The machines are getting faster and faster and humans are staying more or less the same.

Mr. VALVO: Absolutely. Without a doubt. Without a doubt. Many have said the Kasparov is the last human world champion.

Mr. KASPAROV: I don't know. We shall see when I lose my challenge. Because it will happen once. I don't know when, but it will happen. And then, I understand, that's the limit. Right now, there is no limit because I can win any challenge and I have no doubt I didn't use my 100 percent capabilities. Not yet. It wasn't necessary. And that's a great pity for me. I want to— once I want to use fully and for right now, for me, I think it's the only chance, is to face the computer with one billion operations a second. Within five years, I will show my real chess, what really I can do on the chess board.

NARRATOR: That's how it started in the first place, as a way to find out what man and machine could do at the chess board, to find out more about computers and about ourselves.

Prof. NEWELL: After all, when we get through with the mind, we will go back to how humans can feel, so machines, in fact, can't feel sad. They can't feel empathetic. You know, they can't feel sort of joy-

ous and smile. They can't feel good when they get up. They can't feel depressed. So it turns out that those will be the real human things and you can have your ability to think. They will sort of pass in the night as the key things. So it's only now that the key is sort of all on the intellectual activities that we think that's all-important.

Prof. SIMON: And maybe after three rounds, or maybe when there've been more than three rounds of this, we might rethink the whole situation and say "Maybe the important thing isn't our uniqueness at all. Maybe the important thing is that we sit on this little pale blue globe," at least that's the way it looks from space, "along with all the other creatures and the plants and that's where we're going to live for a long time and we'd better learn not how to be unique. We'd better learn how to live with the rest of nature, to be a part of nature."

NARRATOR: At the dawn of the computer age, the first game of chess was played to test the limits of the machine. Now it's the machine that may be testing the limits of man.

Prof. SIMON: We human beings don't really understand ourselves, so I put a very high priority on getting a deeper understanding of human beings, including our thought processes. And I see the computers as having helped us and helping us toward that goal. So I don't think it's important whether a computer can beat people or people can beat computers in chess any more than I think it's important whether race horses can beat marathon runners or marathon runners can beat race horses. That isn't what the human race is all about. But I do think that it's terribly important that we get a deeper understanding of ourselves and if computers can help us do it, which I think they can, obviously, then we ought to be using them to do it.

Mr. KASPAROV: We have some prospects in the future, not only computers. We can find something and create something new beyond the computer's ability, computer's imagination. And if the human being is able to resist this artificial mind, they are successful.

INTERVIEWER: I mean, how will you feel when some day, you do lose to a computer?

Mr. KASPAROV: A single game or the match?

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